References

- Abrams P. (1976) Limiting similarity and the form of the competition coefficient. *Theoretical Population Biology*, 8, 356–75
- Ackert J. E., Graham G. L., Nolf I., O. & Porter D. A. (1931)
 Quantitative studies on the administration of variable
 numbers of nematode eggs (Ascaridia lineata) to chickens.
 Transactions of the American Microscopical Society, 50,
 206–14
- Agricultural Research Council (1965) The Nutritional Requirements of Farm Livestock. 2. Ruminants. Agricultural Research Council, London
- Akinlosotu T. A. (1973) The role of *Diaeretiella rapae* (McIntosh) in the control of the cabbage aphid. Unpublished PhD thesis, University of London
- Allee W. C. (1931) Animal Aggregations. A Study in General Sociology. University of Chicago Press, Chicago
- Anderson R. M. (1974) Population dynamics of the cestode Caryophyllaeus laticeps (Pallas 1781) in the bream (Abramis brama L.). Journal of Animal Ecology, 43, 305–21
- Anderson R. M. (1979) The influence of parasitic infection on the dynamics of host population growth. In *Population Dynamics* (Anderson R. M., Turner B. D. & Taylor L. R. eds), pp. 245–81. Blackwell Scientific Publications, Oxford
- Anderson R. M. (1981) Population ecology of infectious disease agents. In *Theoretical Ecology: Principles and Applica*tions, 2nd edn (R. M. May ed.), pp. 318–55. Blackwell Scientific Publications, Oxford
- Anderson R. M. & May R. M. (1978) Regulation and stability of host-parasite population interactions: 1. Regulatory processes. *Journal of Animal Ecology*, 47, 219–47
- Andrewartha H. G. & Birch L. C. (1954) The Distribution and Abundance of Animals. University of Chicago Press, Chicago
- Andrewartha H. G. & Birch L. C. (1960) Some recent contributions to the study of the distribution and abundance of insects. *Annual Review of Entomology*, 5, 219–42
- Antonovics J. & Levin D. A. (1980) The ecological and genetic consequences of density-dependent regulation in plants. *Annual Reviews of Ecology and Systematics*, 11, 411–52
- Archer S. & Tieszen L. L. (1983) Effects of simulated grazing on foliage and root production and biomass allocation in an arctic tundra sedge (*Eriophorum vaginatum*). *Oecologia*, 58, 92–102
- Atkinson W. D. & Shorrocks B. (1981) Competition on a divided and ephemeral resource: a simulation model. *Journal of Animal Ecology*, 50, 461–71
- Auer C. (1968) Erste Ergebnisse einfacher stochasticher

- Modelluntersuchungen uber die Ursachen der Populations-bewegung des grauen Larchenwicklers Zeiraphera diniana, Gn. (= Z. griseana Hb). in Oberengadin 1949/66. Zeitschrift fuer Angewandte Entomologie, 62, 202–35
- Ayala F. J., Gilpin M. E. & Ehrenfeld J. G. (1973) Competition between species: theoretical models and experimental tests. *Theoretical Population Biology*, 4, 331–56
- Bakker K. (1961) An analysis of factors which determine success in competition for food among larvae of *Drosophila* melanogaster. Archives Neerlandaises de Zoologie, 14, 200–81
- Bakker K. (1964) Backgrounds of controversies about population theories and their terminologies. Zeitschrift fuer Angewandte Entomologie, 53, 187–208
- Banks C. J. (1957) The behaviour of individual coccinellid larvae on plants. *Animal Behaviour*, 5, 12–24
- Baskin J. M. & Baskin C. C. (1980) Ecophysiology of secondary dormancy in seeds of *Ambrosia artemisifolia*. Ecology, 61, 475–80
- Baskin J. M. & Baskin C. C. (1983) Seasonal changes in the germination response of buried seeds of *Arabidopsis thaliana* and ecological interpretation. *Botanical Gazette*, 144, 540–3
- Beddington J. R. (1979) Harvesting and population dynamics. In *Population Dynamics* (Anderson R. M., Turner B. D. & Taylor L. R. eds), pp. 307–20. Blackwell Scientific Publications, Oxford
- Beddington J. R., Free C. A. & Lawton J. H. (1975) Dynamic complexity in predator–prey models framed in difference equations. *Nature*, 225, 58–60
- Beddington J. R., Free C. A. & Lawton J. H. (1978) Modelling biological control: on the characteristics of successful natural enemies. *Nature*, 273, 513–19
- Beddington J. R. & Lawton J. H. (1978) On the structure and behaviour of ecosystems. *Journal de Physique*, **39**(c), 5–39
- Begon M. (1984) Density and individual fitness: asymmetric competition. In *Evolutionary Ecology* (Shorrocks B., ed), pp. 175–194. Blackwell Scientific Publications, Oxford
- Begon M., Harper J. L. & Townsend C. R. (1990) Ecology. Individuals. Populations and Communities (2nd edn). Blackwell Scientific Publications, Oxford, 958 pp
- Bell A. D. & Tomlinson P. B. (1980) Adaptive architecture in rhizomatous plants. *Botanical Journal of the Linnean Society*, 80, 125–60
- Bellows, T. S. & Hassell, M. P. (1988) The dynamics of age-structured host–parasitoid interactions. *Journal of Ani*mal Ecology, 57, 259–68

- Belsky A. J. (1986) Does herbivory benefit plants? A review of the evidence. *American Naturalist*, **127**, 870–92
- Bengtsson J. (1991) Interspecific competition in metapopulations. *Biological Journal of the Linnean Society*, **42**, 219–37
- Beverton R. J. H. & Holt S. J. (1957) On the dynamics of exploited fish populations. *Fishery Investigations, London* (Series II), 19, 1–533
- Birkhead T. R. (1977) The effect of habitat and density on breeding success in the common guillemot (*Uria aalge*). *Journal of Animal Ecology*, **46**, 751–64
- Blackman G. E. (1968) The applications of the concepts of growth analysis to the assessment of productivity. In Functioning of Terrestrial Ecosystems at the Primary Production Level (Eckardt F. E. ed.), pp. 243–59. Unesco, Liege
- Boycott A. E. (1930) A re-survey of the Freshwater Mollusca of the parish of Aldenham after ten years with special reference to the effect of drought. *Transactions of the Hertfordshire Natural History Society*, 19, 1–25
- Bradshaw A. D. (1965) Evolutionary significance of phenotypic plasticity in plants. *Advances in Genetics*, **13**, 115–55
- Branch G. M. (1975) Intraspecific competition in Patella cochlear Born. Journal of Animal Ecology, 44, 263–81
- Brougham R. W. (1955) A study in rate of pasture growth. Australian Journal of Agricultural Research, 6, 804–12
- Brougham R. W. (1956) The rate of growth of short-rotation ryegrass pastures in the late autumn, winter and early spring. New Zealand Journal of Science and Technology, A38, 78–87
- Brown J. H. & Davidson D. W. (1977) Competition between seed-eating rodents and ants in desert ecosystems. *Science*, **196**, 880–2
- Brown M. W. & Cameron E. A. (1979) Effects of disparlure and egg mass size on parasitism by the gypsy moth egg parasite, *Ooencyrtus kuwani. Environmental Entomology*, 8, 77–80
- Bryant J. P. (1981) Phytochemical deterrence of snowshoe hare browsing by adventitious shoots of four Alaskan trees. *Science*, 213, 889–90
- Bulmer, M. G. (1975) The statistical analysis of density dependence. *Biometrics*, **31**, 901–11
- Burnett T. (1954) Influences of natural temperatures and controlled host densities on oviposition of an insect parasite. *Physiological Zoology*, 27, 239–48
- Burnett T. (1956) Effects of natural temperatures on oviposition of various numbers of an insect parasite (Hymenoptera, Chalcididae, Tenthredinidae). *Annals of the Entomological Society of America*, **49**, 55–9
- Burnett T. (1958) Dispersal of an insect parasite over a small plot. *Canadian Entomologist*, **90**, 279–83
- Burrows F. M. (1991) Biomass production, structural deformation, self-thinning and thinning mechanisms in monocultures. *Philosophical Transactions of the Royal Society of London B.* **333**, 119–245

- Carl E. (1971) Population control in arctic ground squirrels. Ecology, 52, 395–413
- Caswell H. (1989) Matrix Population Models. Sinauer Associates, New York
- Caughley G. & Lawton J. H. (1981) Plant–herbivore systems. In *Theoretical Ecology: Principles and Applications*, 2nd edn (May R.M. ed.), pp. 132–66. Blackwell Scientific Publications, Oxford
- Charles-Edwards P. A. (1984) On the ordered development of plants 2. Self-thinning in plant communities. *Annals of Botany* **53**, 709–14
- Chesson P. L. & Murdoch W. W. (1986) Aggregation of risk: relationships among host–parasitoid models. *American Naturalist*, 127, 696–715
- Clark L. R. (1963) The influence of predation by Syrphus spp. on the numbers of Cardiaspina albitextura (Psyllidae). Australian Journal of Zoology, 11, 470–87
- Clark L. R., Geier P. W., Hughes R. D. & Morris R. F. (1967) The Ecology of Insect Populations in Theory and Practice. Methuen, London
- Clarke T. A. (1970) Territorial behaviour and population dynamics of a pomacentrid fish, the Garibaldi, Hypsypops rubicunda. Ecological Monographs, 40, 189–212
- Clements F. E., Weaver J. E. & Hanson H. C. (1929) Competition in cultivated crops. Carnegie Institute of Washington Publications, 398, 202–33
- Comins H. N. & Hassell M. P. (1979) The dynamics of optimally foraging predators and parasitoids. *Journal of Animal Ecology*, 48, 335–51
- Connell J. H. (1961) The influence of interspecific competition and other factors on the distribution of the barnacle *Chthamalus stellatus. Ecology*, **42**, 710–23
- Connell J. H. (1970) A predator–prey system in the marine intertidal region. I. Balanus glandula and several predatory species of Thais. Ecological Monographs, 40, 49–78
- Connell J. H. (1971) On the role of natural enemies in preventing competitive exclusion in some marine animals and in rain forest trees. In *Dynamics of Populations* (den Boer P. J. & Gradwell G. R. eds), pp. 298–312. Centre for Agricultural Publishing and Documentation, Wageningen
- Connell J. H. (1973) Biology and Geology of Coral Reefs. Vol. 2. (Jones, O. A. & Endean, R. eds), Academic Press, New York
- Connell J. H. (1979) Tropical rain forests and coral reefs as open non-equilibrium systems. In *Population Dynamics* (Anderson R. M., Turner B. D. & Taylor L. R. eds), pp. 141–63. Blackwell Scientific Publications, Oxford
- Connolly J. (1986) On difficulties with replacement series methodology in mixture experiments. *Journal of Applied Ecology*, 23, 125–37
- Cook R. M. & Cockrell B. J. (1978) Predator ingestion rate and its bearing on feeding time and the theory of optimal diets. *Journal of Animal Ecology*, 47, 529–48

- Cousens R. (1985) A simple model relating yield loss to weed density Annals of Applied Biology, 107, 239–52
- Crawley, M. J. (1983) Herbivory. The Dynamics of Animal—Plant Interactions. Blackwell Scientific Publications, Oxford
- Crawley M. J. (1985) Reduction of oak fecundity by lowdensity herbivore populations. *Nature*, **314**, 163–4
- Crawley M. J. (1989) Insect herbivores and plant population dynamics *Annual Review Entomology*, **34**, 531–64
- Crawley M. J. (1993) The population dynamics of plants. *Philosophical Transactions of the Royal Society of London B*, **330**, 125–40
- Crawley M. J. & Pacala S. (1991) Herbivores, plant parasites and plant diversity. In *Parasitism: Conflict or Coexistence* (Toft C. ed.), pp. 157–74. Oxford University Press, Oxford
- Crisp D. J. (1961) Territorial behaviour in barnacle settlement. *Journal of Experimental Biology*, 38, 429–46
- Crofton H. D. (1971) A model of host–parasite relationships. *Parasitology*, **63**, 343–64
- Crombie A. C. (1947) Interspecific competition. *Journal of Animal Ecology*, 16, 44–73
- Curio E. (1976) The Ethology of Predation. Springer-Verlag, Berlin
- Davidson D. W. (1977a) Species diversity and community organization in desert seed-eating ants. Ecology, 58, 711–24
- Davidson D. W. (1977b) Foraging ecology and community organization in desert seed-eating ants. *Ecology*. 58, 725–37
- Davidson D. W. (1978) Size variability in the worker caste of a social insect (*Veromessor pergandei* Mayr) as a function of the competitive environment. *American Naturalist*, **112**, 523–32
- Davidson J. (1938) On the growth of the sheep population in Tasmania. *Transactions of the Royal Society of South Australia*, 62, 342-6
- Davidson J. & Andrewartha H. G. (1948a) Annual trends in a natural population of *Thrips imaginis* (Thysanoptera). *Jour*nal of Animal Ecology, 17, 193–9
- Davidson J. & Andrewartha H. G. (1948b) The influence of rainfall, evaporation and atmospheric temperature on fluctuations in the size of a natural population of *Thrips imaginis* (Thysanoptera). *Journal of Animal Ecology*, 17, 200–22
- Davies N. B. (1977) Prey selection and social behaviour in wagtails (Aves: Motacillidae). *Journal of Animal Ecology*, 46, 37–57
- Davies N. B. (1978a) Ecological questions about territorial behaviour. In *Behavioural Ecology: an Evolutionary Approach* (Krebs J. R. & Davies N. B. eds), pp. 317–50. Blackwell Scientific Publications, Oxford
- Davies N. B. (1978b) Territorial defence in the speckled wood butterfly (*Pararge aegeria*), the resident always wins. *Animal Behaviour*, **36**, 138–47

- Davy A. J. & Jeffries R. L. (1981) Approaches to the monitoring of rare plant populations. In *The Biological Aspects of Rare Plant Conservation* (Synge H. ed.), pp. 219–232. John Wiley & Sons, New York
- DeBach P. & Smith H. S. (1941) The effect of host density on the rate of reproduction of entomophagous parasites. *Journal of Economic Entomology*, 34, 741–5
- Dempster, J. P. (1983) The natural control of populations of butterflies and moths. *Biological Reviews*, **58**, 461–81
- de Wit C. T. (1960) On competition. Verslagen van Landbouwkundige Onderzoekinigen, 66, 1-82
- de Wit C. T., Tow P. G. & Ennik G. C. (1966) Competition between legumes and grasses. Verslagen van Landbouwkundige Onderzoekingen, 687, 3–30
- Diamond J. M. (1975) Assembly of species communities. In Ecology and Evolution of Communities (Cody M. L. & Diamond J. M. eds), pp. 342–444. Harvard University Press, Cambridge
- Diamond J. M. & May R. M. (1981) Island biogeography and the design of nature reserves. In *Theoretical Ecology: Principles and Applications*. (R.M. May ed.), pp. 228–52. Blackwell Scientific Publications, Oxford
- Dixon A. F. G. (1971a) The role of aphids in wood formation.
 I. The effect of the sycamore aphid *Drepanosiphum platanoides* (Schr.) (Aphididae) on the growth of sycamore, *Acer pseudoplatanus* (L.). *Journal of Applied Ecology*, 8, 165–79
- Dixon A. F. G. (1971b) The role of aphids in wood formation II. The effect of the lime aphid *Eucallipterus tiliae* L. (Aphididae), on the growth of the lime. *Tilia* × *vulgaris* Hayne. *Journal of Applied Ecology*, **8**, 393–409
- Donald C. M. (1951) Competition among pasture plants.
 I Intraspecific competition among annual pasture plants.
 Australian Journal of Agricultural Research, 2, 355–76
- Donald C. M. (1961) Competition for light in crops and pastures. In *Mechanisms in Biological Competition* (Milnthorpe F. L. ed.), Symposium of the Society of Experimental Biology, No. 15, pp. 283–313
- Dunn E. (1977) Predation by weasels (Mustela nivalis) on breeding tits (Parus spp.) in relation to the density of tits and rodents. Journal of Animal Ecology, 46, 634–52
- Eberhardt L. (1960) Michigan Department of Conservation Game Division Report No 2282
- Ehler L. E. (1987) Patch-exploitation efficiency in a torymid parasite of a gall midge. *Environmental Entomology*, 16, 198–201
- Elner R. W. & Hughes R. N. (1978) Energy maximisation in the diet of the shore crab. Carcinus maenas (L.). Journal of Animal Ecology, 47, 103–16
- Ennos R. (1985) The significance of genetic variation for root growth within a natural population of white clover (*Trifolium repens*). *Journal of Ecology*, 73, 615–24

- Errington P. L. (1946) Predation and vertebrate populations. *Quarterly Review of Biology*, **21**, 144–77
- Erwin T. L. & Scott J. C. (1980) Seasonal and size patterns, trophic structure, and richness of Coleoptera in the tropical arboreal ecosystem: the fauna of the tree *Luehea seemannii* Triana and Planch in the Canal Zone of Panama. *Coleopterists' Bulletin*, **34**, 305–22
- Esau K. (1953) Plant Anatomy. Wiley, New York
- Fenchel T. (1975) Character displacement and coexistence in mud snails (Hydrobiidae). *Oecologia*, **20**, 19–32
- Fernando M. H. J. P. (1977) Predation of the glasshouse red spider mite by *Phytoseiulus persmilis* A.-H. Unpublished PhD thesis, University of London
- Finlayson L. H. (1949) Mortality of *Laemophloeus* (Coleoptera. Cucujidae) infected with *Mattesia dispora* Naville (Protozoa, Schizogregarinaria). *Parasitology*, **40**, 261–4
- Firbank L. G., Cousens R., Mortimer A. M. & Smith R. R. (1990) Effects of soil type on crop yield—weed density relationships. *Journal of Applied Ecology*, 27, 308–318
- Firbank L. G. & Watkinson A. R. (1985) On the analysis of competition within two-species mixtures of plants. *Journal* of Applied Ecology, 22, 503–17
- Firbank L. G. & Watkinson A. R. (1990) On the effects of competition: from monocultures to mixtures. In *Perspec*tives on *Plant Competition* (Grace J. B. & Tilman D. eds), pp. 165–92. Academic Press, San Diego
- Ford E. D. (1975) Competition and stand structure in some even-aged plant monocultures. *Journal of Ecology*, 63, 311–33
- Free C. A., Beddington J. R. & Lawton J. H. (1977) On the inadequacy of simple models of mutual interference for parasitism and predation. *Journal of Animal Ecology*, 46, 543–54
- Fujii K. (1967) Studies on interspecies competition between the azuki bean weevil Callosobruchus chinensis and the southern cowpea weevil, C. maculatus. II. Competition under different environmental conditions. Researches in Population Ecology, 9, 192–200
- Fujii K. (1968) Studies on interspecies competition between the azuki bean weevil and the southern cowpea weevil: III, some characteristics of strains of two species. *Researches in Population Ecology*, **10**, 87–98
- Garwood N. C. (1989) Tropical soil seed banks: a review. In *Ecology of soil seed banks* (Leck M. A., Parker V. T. & Simpson R. L. eds), pp. 149–210. Academic Press, San Diego
- Gaston K. J. & Lawton J. H. (1990) Effects of scale and habitat on the relationship between regional distribution and local abundance. *Oikos*, 58, 329–35
- Gatsuk, L. E., Smirnova, O. V., Vorontzova, L. I., Zaugolnova,
 L. B. & Zhukova, L. A. (1980) Age states of plants of various growth forms: a review. *Journal of Ecology*, 68, 675-96

- Gause G. F. (1934) The Struggle for Existence. Williams and Wilkins, Baltimore. (Reprinted 1964, by Hafner, New York)
- Gill F. B. & Wolf L. L. (1975) Economics of feeding territoriality in the golden-winged sunbird. *Ecology*, **56**, 333–45
- Gilpin M. & Hanski I. (1991) Metapopulation Dynamics: Empirical and Theoretical Investigations. Academic Press, London
- Godfray H. C. J., Cook L. M. & Hassell M. P. (1991) Population dynamics, natural selection and chaos. In *Genes in Ecology*. (Berry R. J., Crawford T. J. & Hewitt G. M. eds), Symposium of the British Ecological Society No. 33, pp. 55–86 Blackwell Scientific Publications, Oxford
- Goh B. S. (1978) Robust stability concepts for ecosystem models. In *Theoretical Systems Ecology* (Halfon E. ed.), Academic Press, New York
- Gold W. G. & Caldwell M. M. (1989) The effects of the spatial pattern of defoliation on regrowth of a tussock grass. II Canopy gas exchange. *Oecologia*, **81**, 437–42
- Goldberg D. E. (1987) Neighborhood competition in an old-field plant community. Ecology, 68, 1211–33
- Goldberg D. E. (1990) Components of resource competition in plant communities. In *Perspectives on Plant Competition* (Grace J. B. & Tilman D. eds), pp. 27–50. Academic Press, San Diego
- Gorman M. L. (1979) *Island Ecology*. Chapman and Hall, London
- Gotelli N. J. (1991) Metapopulation models: the rescue effect, the propagule rain, and the core-satellite hypothesis. American Naturalist, 138, 768–76
- Gottleib L. D. (1984) Genetics and morphological evolution in plants. *American Naturalist*, **123**, 681–709
- Griffiths K. J. (1969) Development and diapause in *Pleolophus basizonus* (Hymenoptera: lchneumonidae). *Canadian Entomologist*, **101**, 907–14
- Grubb P. J. (1977) The maintenance of species richness in plant communities: the importance of the regeneration niche. *Biological Reviews*, **52**, 107–45
- Gulland J. A. (1962) The application of mathematical models to fish populations. In *The Exploitation of Natural Animal Populations* (Le Cren E. D. & Holdgate M. W. eds), Symposium of the British Ecological Society No. 2, pp. 204–17. Blackwell Scientific Publications, Oxford
- Haines B. (1975) Impact of leaf cutting ants on vegetation development at Barro Colorado Island. In *Tropical Ecological Systems—Trends in Terrestrial and Aquatic Research* (Golley F. B. & Medina E. eds), pp. 99–111. Springer-Verlag, New York
- Haldane J. B. S. (1949) Disease and evolution. Symposium sui fattori ecologici e genetici della speciazone negli animali. *Ric. Sci.* 19 (suppl.), 3–11
- Hancock D. A. (1979) Population dynamics and management of

- shellfish stocks. ICES Special Meeting on Population Assessment of Shellfish
- Hanski I. (1981) Coexistence of competitors in patchy environments with and without predation. Oikos, 37, 306–12
- Hanski I. (1982) Dynamics of regional distribution: the core and satellite hypothesis. Oikos, 38, 210–21
- Hanski I. (1987) Colonisation of ephemeral habitats. In Colonization, Succession and Stability. (Gray A. J., Crawley M. J. & Edwards P. J. eds), Symposium of the British Ecological Society No. 26, pp. 155–85. Blackwell Scientific Publications, Oxford
- Hanski I. (1989) Metapopulation dynamics: does it help to have more of the same? *Trends in Ecology and Evolution*, 4, 113–14
- Hanksi I. (1990) Density dependence, regulation and variability in animal populations. *Philosophical Transactions of the Royal Society of London B.* 330, 141–50
- Hanski I. (1991) Single-species metapopulation dynamics: concepts, models and observations. Biological Journal of the Linnean Society, 42, 17–38
- Hanski I. & Gilpin M. (1991) Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linnean Society, 42, 3–16
- Hanski I. & Kuuscla S. (1977) An experiment on competition and diversity in the carrion fly community. *Annales Zoo-logici Fennici*, 43, 108–15
- Hanski I., Turchin P., Korpimaki E. & Henttonen H. (1993) Population oscillations of boreal rodents: regulation by mustelid predators leads to chaos. *Nature*, 364, 232–5
- Hanski I. & Woiwod I. P. (1991) Delayed density dependence Nature, 350, 28
- Hara T. (1988) Dynamics of size structure in plant populations. Trends in Ecology and Evolution 3, 129–33
- Harberd D. J. (1961) Some observations on natural clones in Festuca ovina L. New Phytologist, 60, 184–206
- Harcourt D. G. (1964) Population dynamics of Leptinotarsa decemlineata (Say) in eastern Ontario. II. Population and mortality estimation during six age intervals. Canadian Entomologist, 96, 1190–8
- Harcourt D. G. (1971) Population dynamics of Leptinotarsa decemlineata (Say) in castern Ontario. III. Major population processes. Canadian Entomologist, 103, 1049–61
- Harper J. L. (1977) The Population Biology of Plants. Academic Press, London and New York
- Harper J. L. (1981) The concept of population in modular organisms. In *Theoretical Ecology* (May R. ed.), Blackwell Scientific Publications, Oxford
- Harper J. L. (1985) Modules, branches and the capture of resources. In *Population Biology and Evolution of Clonal Organisms* (Jackson J. B. C., Buss L. W. & Cook R. E. eds), pp 1–34. Yale University Press, New Haven
- Harper J. L. (1989) The value of a leaf. *Oecologia*, **80**, 53–8 Harper J. L. & Bell A. D. (1979) The population dynamics of

- growth form in organisms with modular construction. In *Population Dynamics* (Anderson R. M., Turner B. D. & Taylor L. R. eds), pp. 29–52. Blackwell Scientific Publications, Oxford
- Harrison S. (1991) Local extinction in a metapopulation context: an empirical evaluation. *Biological Journal of the Linnean Society*, 42, 73–88
- Harrison S., Murphy D. D. & Ehrlich P. R. (1988) Distribution of the bay checkerspot butterfly, Euphydryas editha bayensis: evidence for a metapopulation model. American Naturalist, 132, 360–82.
- Hassell M. P. (1971a) Mutual interference between searching insect parasites. *Journal of Animal Ecology*, 40, 473–86
- Hassell M. P. (1971b) Parasite behaviour as a factor contributing to the stability of insect host–parasite interactions. In *Dynamics of Populations*, (den Boer P. J. & Gradwell G. R. eds), pp. 366–79. Centre for Agricultural Publishing and Documentation, Wageningen
- Hassell M. P. (1975) Density-dependence in single-species populations. *Journal of Animal Ecology*, 44, 283–95
- Hassell M. P. (1976) The Dynamics of Competition and Predation. Edward Arnold, London
- Hassell M. P. (1978) The Dynamics of Arthropod Predator-Prey Systems. Princeton University Press, Princeton
- Hassell M. P. (1985) Insect natural enemies as regulating factors. Journal of Animal Ecology, 54, 323-34
- Hassell M. P. & Comins, H. N. (1976) Discrete time models for two-species competition. *Theoretical Population Biology*, 9, 202–21
- Hassell M. P. & Comins H. N. (1978) Sigmoid functional responses and population stability. *Theoretical Population Biology*, 14, 62–7
- Hassell M. P., Latto J. & May R. M. (1989) Seeing the wood for the trees: detecting density dependence from existing life-table studies. *Journal of Animal Ecology*, 58, 883–92
- Hassell M. P., Lawton J. H. & Beddington J. R. (1977) Sigmoid functional responses by invertebrate predators and parasitoids. *Journal of Animal Ecology*, 46, 249–62
- Hassell M. P., Lawton J. H. & May R. M. (1976) Patterns of dynamical behaviour in single species populations. *Journal* of Animal Ecology, 45, 471–86
- Hassell M. P. & May R. M. (1973) Stability in insect hostparasite models. *Journal of Animal Ecology*, 42, 693–736
- Hassell M. P. & May R. M. (1974) Aggregation of predators and insect parasites and its effect on stability. *Journal of Animal Ecology*, 43, 567–94
- Hassell, M. P. & Pacala, S. W. (1990) Heterogeneity and the dynamics of host-parasitoid interactions. *Philosophical Transactions of the Royal Society of London*, B, 330, 203–20
- Hassell M. P., Pacala S. W., May R. M. & Chesson P. L. (1991) The persistence of host–parasitoid associations in patchy environments. I. A general criterion. *American Naturalist*, 138, 568–83

- Hassell M. P. & Rogers D. J. (1972) Insect parasite responses in the development of population models. *Journal of Animal Ecology*, 41, 661–76
- Hassell M. P., Southwood T. R. E. & Reader P. M. (1987) The dynamics of the viburnum whitefly (Aleurotrachelus jelinekii): a case study of population regulation. Journal of Animal Ecology, 56, 283–300
- Hassell M. P. & Varley G. C. (1969) New inductive population model for insect parasites and its bearing on biological control. *Nature*, 223, 1133–6
- Hastings A., Hom C. L., Ellner S., Turchin P. & Godfray H. C. J. (1993) Chaos in ecology: is mother nature a strange attractor? *Annual Review of Ecology and Systematics*, **24**, 1–33
- Hatto J. & Harper J. L. (1969) The control of slugs and snails in British cropping systems, specially grassland. *International Copper Research Association Project* 115(A), 1–25
- Heads P. A. & Lawton J. H. (1983) Studies on the natural enemy complex of the holly leaf-miner: the effect of scale on the aggregative responses and the implications for biological control. *Oikos*, **40**, 267–76
- Healey M. C. (1967) Aggression and self regulation of population size in deermice. *Ecology*, **48**, 377–92
- Heed W. B., Starmer W. T., Miranda M., Miller M. W. & Phaff H. S. (1976) An analysis of the yeast flora associated with cactiphilic *Drosophila* and their host plants in the Sonoran Desert and its relation to temperate and tropical associations. *Ecology*, 57, 151–60
- Hodgson G. L. & Blackman G. E. (1956) An analysis of the influence of plant density on the growth of *Vicia faba* 1. The influence of density of the pattern of development. *Journal* of experimental Botany, 7, 147–65
- Holling C. S. (1959) Some characteristics of simple types of predation and parasitism. *Canadian Entomologist*, 91, 385–98
- Holling C. S. (1965) The functional response of predators to prey density and its role in mimicry and population regulation. *Memoirs of the Entomological Society of Canada*, **45**, 43–60
- Holling C. S. (1966) The functional response of invertebrate predators to prey density. *Memoirs of the Entomological Society of Canada*, **48**, 1–86
- Hoppensteadt F. C. (1982) Mathematical Methods of Population Biology. Cambridge University Press, Cambridge
- Horn H. S. (1971) *The Adaptive Geometry of Trees*. Princeton University Press, Princeton
- Horton K. W. (1964) Deer prefer Jack Pine. *Journal of Forestry*, **62**, 497–9
- Hubbard S. F. (1977) Studies on the natural control of *Pieris brassicae* with particular reference to parasitism by *Apanteles glomeratus*. Unpublished D Phil thesis, University of Oxford
- Huffaker C. B. (1958) Experimental studies on predation: dispersion factors and predator-prey oscillations. *Hilgar-dia*, 27, 343–83

- Huffaker C. B. & Kennett C. E. (1959) A 10 year study of vegetational changes associated with biological control of Klamath weed species. *Journal of Range Management*, 12, 69–82
- Huffaker C. B., Shea K. P. & Herman S. G. (1963) Experimental studies on predation. *Hilgardia*, **34**, 305–30
- Hughes T. P. (1984) Population dynamics based on individual size rather than age: a general model with a reef coral example. American Naturalist, 123, 778–95
- Hutchings M. J. (1985) The structure of plant populations In Plant Ecology (Crawley, M. J. ed.), pp. 97–136. Blackwell Scientific Publications, Oxford
- Hutchinson G. E. (1957) Concluding remarks. Cold Spring Harbour Symposium on Quantitative Biology, 22, 415–27
- Iles T. D. (1973) Interaction of environment and parent stock size in determing recruitment in the Pacific sardine as revealed by analysis of density-dependent O-group growth. Rapports et Procesverbaux, Conseil International pour l'Explortion de la Mer, 164, 228–40
- Inouye D. W. (1978) Resource partitioning in bumblebees: experimental studies of foraging behaviour. *Ecology*, **59**, 672–8
- Ives A. R. (1991) Aggregation and coexistence in a carrion fly community. Ecological Monographs, 61, 75–94
- Ives A. R. (1992a) Continuous-time models of host–parasitoid interactions. American Naturalist, 140, 1–29
- lves A. R. (1992b) Density-dependent and density-independent parasitoid aggregation in model host-parasitoid systems. *American Naturalist*, 140, 912–37
- Janzen D. H. (1966) Coevolution of mutualism between ants and acacias in Central America. Evolution, 20, 249–75
- Janzen D. H. (1971) Escape of juvenile *Dioclea megacarpa* (Leguminosae) vines from predators in a deciduous tropical forest. *American Naturalist*, **105**, 97–112
- Janzen D. H. (1972a) Association of a rainforest palm and seed-eating beetles in Puerto Rica. *Ecology*, **53**, 258–61
- Janzen D. H. (1972b) Escape in space by *Sterculia apetala* seeds from the bug *Dysdercus fasciatus* in a Costa Rican deciduous forest. *Ecology*, **53**, 350–61
- Janzen D. H. (1975) Interactions of seeds and their insect predators/parasitoids in a tropical deciduous forest. In Evolutionary Strategies of Parasitic Insects and Mites (Price P. W. ed.), pp. 154–86. Plenum, New York
- Jónsdóttir I. S. & Callaghan T. V. (1988) Interrelationships between different generations of interconnected tillers of Carex bigelowii. Oikos, 52, 120–8
- Jordano D. & Thomas C. D. (1992) Specificity of an ant-lycaenid interaction. *Oecologia*, **91**, 431–8
- Kaban R. & Myers J. H. (1989) Induced plant responses to herbivory. Annual Review Ecology and Systematics, 20, 331–48

- Kays S. & Harper J. L. (1974) The regulation of plant and tiller density in a grass sward. *Journal of Ecology*, 62, 97–105
- Keddy P. A. (1981) Experimental demography of the sand dune annual *Cakile edentula* growing along an environmental gradient in Nova Scotia. *Journal of Ecology*, **69**, 615–30
- Keith L. B. (1963) Wildlife's Ten-year Cycle. University of Wisconsin Press, Madison
- Kira T., Ogawa H. & Shinozaki K. (1953) Intraspecific competition among higher plants. I. Competition–density– yield interrelationships in regularly dispersed populations. *Journal of the Polytechnic Institute, Osaka City University*, 4(4), 1–16
- Klomp H. (1964) Intraspecific competition and the regulation of insect numbers. Annual Review of Entomology, 9, 17–40
- Kluyver H. N. (1951) The population ecology of the great tit. *Parus m. major L. Ardea*, **38**, 1–135.
- Konthanen P. (1950) Quantitative and seasonal studies on the leafhopper fauna of the field stratum on open areas of North Karelia. Annales Zoologici Society 'Vanamo', 13, 1–91
- Krebs J. R. (1971) Territory and breeding density in the great tit. Parus major L. Ecology, 52, 2–22
- Krebs J. R. (1978) Optimal foraging: decision rules for predators. In *Behavioural Ecology: an Evolutionary Approach* (Krebs J. R. & Davies N. B. eds), pp. 23–63. Blackwell Scientific Publications, Oxford
- Krebs J. R., Kacelnik A. & Taylor P. J. (1978) Test of optimal sampling by foraging great tits. *Nature*, **275**, 27–31
- Kuchlein J. H. (1966) Mutual interference among the predacious mite *Typhlodromus longipilus* Nesbitt (Acari, Phytoseiidae). I. Effects of predator density on oviposition rate and migration tendency. *Mededelingen Rijksfaculteit Landbouwwetenschappen te Gent*, 31, 740-6
- Lack D. (1971) Ecological Isolation in Birds. Blackwell Scientific Publications, Oxford
- Lanciani C. A. (1975) Parasite-induced alterations in host reproduction and survival. *Ecology*, 56, 689–95
- Langer R. H. M. (1956) Growth and nutrition of timothy (Phleum pratense). The life history of individual tillers. Annals of Applied Biology, 44, 166–87
- Law R. (1975) Colonisation and the evolution of life histories in *Poa annua*. Unpublished PhD thesis, University of Liverpool
- Law R. (1979) Harvest optimisation in populations with age distributions. *American Naturalist*, 114, 250–9
- Law R. & Watkinson A. R. (1987) Response-surface analysis of two-species competition: an experiment on *Phleum arenar*ium and *Vulpia fasiculata*. *Journal of Ecology*, 75, 871–86
- Lawrence W. H. & Rediske J. H. (1962) Fate of sown douglas-fir seed. Forest Science, 8, 211–18
- Lawton J. H., Beddington J. R. & Bonser R. (1974) Switching in invertebrate predators. In *Ecological Stability* (Usher M. B. & Williamson M. H. eds), pp. 141–58. Chapman & Hall, London

- Lawton J. H. & McNeill S. (1979) Between the devil and the deep blue sea: on the problem of being a herbivore. In Population Dynamics (Anderson R. M., Turner B. D. & Taylor L. R. eds), pp. 223–44. Blackwell Scientific Publications, Oxford
- Lawton J. H. & Pimm S. L. (1978) Population dynamics and the length of food chains. *Nature*, 272, 190
- Leslie P. H. (1945) On the use of matrices in certain population mathematics. *Biometrika*. **33**, 183–212
- Levins R. (1968) Evolution in Changing Environments. Princeton University Press, Princeton
- Levins R. (1969) Some demographic and genetic consequences of environmental heterogeneity for biological control. *Bulletin of the Entomological Society of America*, 15, 237–40
- Levins R. (1970) Extinction. In Some mathematical problems in biology. (Gerstenhaber M. ed.), pp. 77–107, American Mathematical Society, Providence, R.I.
- Lonsdale W. M. (1990) The self-thinning rule: dead or alive? *Ecology*, 71, 1373–88
- Lonsdale W. M. & Watkinson A. R. (1982) Light and self-thinning. New Phytologist, 90, 431–45
- Lotka A. J. (1925) Elements of Physical Biology. Williams & Wilkins, Baltimore
- Lowe V. P. W. (1969) Population dynamics of the red deer (Cervus elaphus L.) on Rhum. Journal of Animal Ecology, 38, 425–57
- MacArthur R. H. (1965) Patterns of species diversity. Biological Reviews, 40, 1510–33
- MacArthur R. H. (1972) Geographical Ecology. Harper Row, New York
- MacArthur R. H. & Levins R. (1967) The limiting similarity, convergence and divergence of coexisting species. *American Naturalist*, 101, 377–85
- MacArthur R. H. & Pianka E. R. (1966) On optimal use of a patchy environment. *American Naturalist*, 100, 603–9
- MacArthur R. H. & Wilson E. O. (1967) The Theory of Island Biogeography. Princeton University Press, Princeton
- MacLulick D. A. (1937) Fluctuations in the numbers of the varying hare (*Lepus americanus*). *University of Toronto Studies*, *Biology Series*, **43**, 1–136
- Manlove, R. J. (1985) On the population ecology of *Avena fatua* L. Unpublished PhD thesis, University of Liverpool
- Marshall D. R. & Jain S. K. (1969) Interference in pure and mixed populations of *Avena fatua* and *A. barbata. Journal of Ecology*, 57, 251–70
- May R. M. (1972) Will a large complex system be stable? *Nature*, **238**, 13–14
- May R. M. (1973) Stability and Complexity in Model Ecosystems.

 Princeton University Press, Princeton
- May R. M. (1974) Biological populations with non-overlapping generations: stable points, stable cycles and chaos. *Science*, **186**, 645–7
- May R. M. (1975) Biological populations obeying difference

- equations: stable points, stable cycles and chaos. *Journal of Theoretical Biology*, **49**, 511–24
- May R. M. (1976) Simple mathematical models with very complicated dynamics. *Nature*, 261, 459–67
- May R. M. (1977) Thresholds and breakpoints in ecosystems with a multiplicity of stable states. *Nature*, **269**, 471–7
- May R. M. (1978a) Host–parasitoid systems in patchy environments: a phenomenological model. *Journal of Ani*mal Ecology, 47, 833–43
- May R. M. (1978b) The dynamics and diversity of insect faunas. In *Diversity of Insect Faunas*. (Mound L. A. & Waloff N. eds), pp. 188–204. Blackwell Scientific Publications, Oxford
- May R. M. (1979) The structure and dynamics of ecological communities. In *Population Dynamics* (Anderson R. M., Turner B. D. & Taylor L. R. eds), pp. 385–407. Blackwell Scientific Publications, Oxford
- May R. M. (1988) How many species are there on Earth? *Science*, **241**, 1441–9
- May R. M. & Anderson R. M. (1978) Regulation and stability of host–parasite population interactions. II. Destabilizing processes. *Journal of Animal Ecology*, **47**, 249–68
- May R. M. & Oster G. F. (1976) Bifurcations and dynamic complexity in simple ecological models. *American Natural*ist, 110, 573–99
- Maynard Smith J. (1976) Group selection. Quarterly Review of Biology, 51, 277–83
- McClure M. S. (1977) Parasitism of the scale insect, *Fiorinia externa* (Homoptera: Diaspididae) by *Aspidiotiphagus citrinus* (Hymenoptera: Eulophidae), in a hemlock forest: density dependence. *Environmental Entomology*, 6, 551–55
- McNaughton S. J. (1983) Physiological and ecological implications of herbivory. *Encyclopaedia of Plant Physiology: Physiological Plant Ecology III Responses to the chemical and biological environment* (Lange O. L., Nobel P. S., Osmond C. B. & Zeigler H. eds), pp. 657–77. Springer-Verlag, Berlin
- McNeill S. & Southwood T. R. E. (1978) The role of nitrogen in the development of insect/plant relationships. In *Biochemical Aspects of Plant and Animal Coevolution* (Harborne J. B. ed.), pp. 77–98. Academic Press, London and New York
- Mead-Briggs A. R. & Rudge A. J. B. (1960) Breeding of the rabbit flea, *Spilopsyllus cuniculi* (Dale): requirement of a 'factor' from a pregnant rabbit for ovarian maturation. *Nature*, 187, 1136–7
- Mertz R. W. & Boyce S. G. (1956) Age of oak 'seedlings'. Journal of Forestry, 54, 774–75
- Michelakis S. (1973) A study of the laboratory interaction between *Coccinella septempunctata* larvae and its prey *Myzus persicae*. Unpublished MSc thesis. University of London
- Monro J. (1967) The exploitation and conservation of resources by populations of insects. *Journal of Animal Ecology*, 36, 531–47

- Moore N. W. (1964) Intra- and interspecific competition among dragonflies. *Journal of Animal Ecology*, 33, 49–71
- Morris R. F. (1959) Single-factor analysis in population dynamics. *Ecology*, 40, 580–8
- Mortimer A. M., Sutton J. J. & Gould P. (1989) On robust weed population models. *Weed Reseach*, 29, 229–38
- Mueller L. D. & Ayala F. J. (1981) Dynamics of single-species population growth: stability or chaos? *Ecology*. **62**, 1148–54
- Murdoch W. W. (1969) Switching in general predators: experiments on predator specificity and stability of prey populations. *Ecological Monographs*, **39**, 335–54
- Murdoch W. W. & Oaten A. (1975) Predation and population stability. *Advances in Ecological Research*, **9**, 2–131
- Murdoch W. W. & Stewart-Oaten A. (1989) Aggregation by parasitoids and predators: effects on equilibrium and stability. American Naturalist, 134, 288–310
- Murphy G. I. (1967) Vital statistics of the Pacific sardine (*Sardinops caerulea*) and the population consequences. *Ecology*, **48**, 731–6
- Murton R. K. (1971) The significance of a specific search image in the feeding behaviour of the wood pigeon. *Behaviour*, **40**, 10–42
- Murton R. K., Westwood N. J. & Isaacson A. J. (1964) The feeding habits of the wood pigeon Columba palumbus, stock dove, C. oenas and the turtle dove, Streptopelia turtur. Ibis, 106, 174–88
- Nault A. & Gagnon D. (1993) Ramet demography of Allium tricoccum a spring ephemeral, perennial forest herb. Journal of Ecology, 81, 101–19
- Newsome A. E. (1969a) A population study of house-mice temporarily inhabiting a South Australian wheatfield. Journal of Animal Ecology. 38, 341–60
- Newsome A. E. (1969b) A population study of house-mice permanently inhabiting a reed-bed in South Australia. *Journal of Animal Ecology*, **38**, 361–77
- Nicholson A. J. (1933) The balance of animal populations. *Journal of Animal Ecology*, **2**, 131–78
- Nicholson A. J. (1954a) Compensatory reactions of populations to stress, and their evolutionary significance. *Australian Journal of Zoology*, 2, 1–8
- Nicholson A. J. (1954b) An outline of the dynamics of animal populations. *Australian Journal of Zoology*. **2**, 9–65
- Nicholson A. J. (1957) *The Self-adjustment of Populations to Change*. Cold Spring Harbour Symposium in Quantitative Biology, No. 22, pp. 153–72
- Nicholson A. J. (1958) Dynamics of insect populations. Annual Review of Entomology, 3, 107–36
- Nicholson A. J. & Bailey V. A. (1935) The balance of animal populations. Proceedings of the Zoological Society of London, 3, 551–98
- Noyes J. S. (1974) The biology of the leek moth, Acrolepia

- assectella (Zeller). Unpublished PhD thesis, University of London
- Noy-Meir I. (1975) Stability of grazing sytems: an application of predator–prey graphs. *Journal of Ecology*, **63**, 459–83
- Obeid M., Machin D. & Harper J. L. (1967) Influence of density on plant to plant variations in Fiber Flax, *Linum usitatissimum*. *Crop Science*, 7, 471–3
- Oinonen E. (1967) The correlation between the size of Finnish bracken (*Pteridium aquilinum* (L.) Kuhn) clones and certain periods of site history. *Acta Forestalia Fennica*, **83**, 1–51
- Osawa A. & Sugita S. (1989) The self-thinning rule: another interpretation of Weller's results. *Ecology*, **70**, 279–83
- Pacala S. W. & Hassell M. P. (1991) The persistence of host–parasitoid associations in patchy environments. II. Evaluation of field data. *American Naturalist*, 138, 584–605
- Pacala S. W., Hassell M. P. & May R. M. (1990) Hostparasitoid associations in patchy environments. *Nature*, 344, 150-3
- Pacala S. W. & Silander J. A. (1985) Neighbourhood models of plant population dynamics. I. Single-species models of annuals. *American Naturalist*, 125, 385–411
- Paine R. T. (1966) Food web complexity and species diversity. *American Naturalist*, **100**, 65–75
- Palmblad I. G. (1968) Competition studies on experimental populations of weeds with emphasis on the regulation of population size. *Ecology*, **49**, 26–34
- Park T. (1954) Experimental studies of interspecific competition. II. Temperature, humidity and competition in two species of *Tribolium. Physiological Zoology*, **27**, 177–238
- Pearl R. (1927) The growth of populations. *Quarterly Review of Biology*, 2, 532–48
- Pearl R. (1928) The Rate of Living. Knopf, New York
- Perrins C. M. (1965) Population fluctuation and clutch-size in the great tit (*Parus major* L.). *Journal of Animal Ecology*, **34**, 601–47
- Perry J. N., Woiwod I. P. & Hanski I. (1993) Using responsesurface methodology to detect chaos in ecological time series. Oikos, 68, 329–39
- Pilbeam C. J., Hebblethwaite P. D., Ricketts, H. E. & Nyongesa T. E. (1991) Effects of plant population density on determinate and indeterminate growth forms of winter field beans (*Vicia faba*) 1. Yield and yield components. *Journal of Agricultural Science*, 116, 375–84
- Pimentel D. (1961) On a genetic feed-back mechanism regulating populations of herbivores, parasites and predators. *American Naturalist*, **95**, 67–79.
- Pimm S. L. & Lawton J. H. (1977) Number of trophic levels in ecological communities. *Nature*, **268**, 329–31
- Pimm S. L. & Lawton J. H. (1978) On feeding on more than one trophic level. *Nature*, 275, 542–4
- Pimm S. L. & Lawton J. H. (1980) Are foodwebs divided into

- compartments? Journal of Animal Ecology, 49, 879-98
- Piper E. L. & Weiss A. (1993) Defoliation during vegetative growth of corn—the shoot–root ratio and yield implications. Field Crops Research, 31, 145–53
- Podoler H. & Rogers D. (1975) A new method for the identification of key factors from life-table data. *Journal of Animal Ecology*, **44**, 85–114
- Pollard E., Lakhani K. L. & Rothery P. (1987) The detection of density dependence from a series of annual censuses. *Ecology*, 68, 2046–55
- Poole R. W. (1978) An Introduction to Quantitative Ecology. McGraw-Hill, New York
- Porter J. R. (1983a) A modular approach to analysis of plant growth. I. Theory and principles. New Phytologist, 94, 183–90
- Porter J. R. (1983b) A modular approach to analysis of plant growth. II. Methods and results. New Phytologist, 94, 191–20
- Pratt D. M. (1943) Analysis of population development in *Daphnia* at different temperatures. *Biological Bulletin*, **85**, 116–40
- Price P. W. (1980) Evolutionary Biology of Parasites. Princeton University Press, Princeton
- Puckridge D. W. & Donald C. M. (1967) Competition among wheat plants sown at a wide range of densities. Australian Journal of Agricultural Research, 17, 193–211
- Putwain P. D. & Harper J. L. (1970) Studies on the dynamics of plant populations. III. The influence of associated species on populations of *Rumex acetosa* L. and *R. acetosella* L. in grassland. *Journal of Ecology*. **58**, 251–64
- Radovich J. (1962) Effects of sardine spawning stock size and environment on year-class production. California Department Fish and Game Bulletin, 48, 123–40
- Randolph S. E. (1975) Patterns of distributions of the tick *Ixodes trianguliceps* Birula, on its host. *Journal of Animal Ecology*, **44**, 451–74
- Raup M. J. & Tallamy, D. W. (1990). Phytochemical Induction by Herbivores. John Wiley & Sons, New York
- Redfern M., Jones T. H. & Hassell M. P. (1992) Heterogeneity and density dependence in a field study of a tephritid– parasitoid interaction. *Ecological Entomology*, 17, 255–62
- Rees M. & Crawley M. J. (1989) Growth, reproduction and population dynamics. *Functional Ecology*, **3**, 645–53
- Rice B. & Westoby M. (1988) Evidence against the hypothesis that ant dispersed seeds reach nutrient-enriched microsites. *Ecology*, 67, 1270–4
- Richards O. W. & Waloff N. (1954) Studies on the biology and population dynamics of British grasshoppers. *Anti-Locust Bulletin*, 17, 1–182
- Richman S. (1958) The transformation of energy by *Daphnia pulex*. *Ecological Monographs*, **28**, 273–91
- Ricker W. E. (1954) Stock and recruitment. Journal of the

- Fisheries Research Board of Canada, 11, 559-623.
- Rigler F. II. (1961) The relation between concentration of food and feeding rate of *Daphnia magna Straus*. Canadian Journal of Zeology, 39, 857–68
- Roberts E. H. (1972) Dormancy: a factor affecting seed survival in the soil. In *Viability of seeds* (Roberts E. H. ed.), pp. 321–59. Chapman Hall, London
- Roberts H. A. & Dawkins P. A. (1967) Effect of cultivation on the numbers of viable weed seeds in the soil. Weed Research, 7, 290–301
- Root R. B. (1967) The niche exploitation pattern of the blue-gray gnatcatcher. Ecological Monographs, 37, 317–50
- Rosen B. R. (1979) Modules, members and communes: a postscript introduction to social organisms. In *Biology and Systematics of Colonial Organisms* (Larwood G. & Rosen B. R. eds), Academic Press, London
- Rosenzweig M. L. & MacArthur R. H. (1963) Graphical representation and stability conditions of predator-prey interactions. *American Naturalist*, 97, 209–23
- Rosewell J., Shorrocks B. & Edwards K. (1990) Competition on a divided and ephemeral resource: testing the assumptions.
 I. Aggregation. *Journal of Animal Ecology*, 59, 977–1001
- Ross M. A. & Harper J. L. (1972) Occupation of biological space during seedling establishment. *Journal of Ecology*, 60, 77–88
- Rotheray G. E. (1979) The biology and host searching behaviour of a cynipoid parasite of aphidophagous syrphid larvae. *Ecological Entomology*, 4, 175–82
- Sagar G. R. & Mortimer A. M. (1976) An approach to the study of the population dynamics of plants with special reference to weeds. *Applied Biology*, 1, 1–43
- Sarukhan J. (1980) Demographic problems in a tropical system. In *Demography and Evolution in Plant Populations* (Solbrig O.T. ed.), pp. 161–88. Blackwell Scientific Publications, Oxford
- Sarukhan J. & Gadgil M. (1974) Studies on plant demography: Ranunculus repens L., R. bulbosus L., and R. acris L. III. A mathematical model incorporating multiple modes or reproduction. Journal of Ecology, 62, 921–36
- Sarukhan J. & Harper J. L. (1973) Studies on plant demography: Ranunculus repens L., R. bulbosus L., and R. acris L. I. Population flux and survivorship. Journal of Ecology, 61, 675–716
- Schaefer M. B. (1957) A study of the dynamics of the fishery for yellow fin tuna in the eastern tropical Pacific ocean. Inter-American Tropical Tuna Commission Bulletin 2, No. 6 1957
- Schoener T. W. (1974) Resource partitioning in ecological communities. Science, 185, 27–39
- Searle S. R. (1966) Matrix Algebra for the Biological Sciences. John Wiley & Sons, New York
- Sharitz R. R. & McCormick J. F. (1973) Population dynamics

- of two competing annual plant species. *Ecology*, 54, 723-40
- Shinozaki K. & Kira T. (1956) Intraspecific competition among higher plants. VII. Logistic theory of the C-D effect. Journal of Institute Polytechnic of Osaka City University, 7, 35-72
- Shorrocks B. (1970) Population fluctuations in the fruit fly (*Drosophila melanogaster*) maintained in the laboratory. *Journal of Animal Ecology*, **39**, 229–53
- Shorrocks B. & Rosewell J. (1987) Spatial patchiness and community structure: coexistence and guild size of *Drosophila* on ephemeral resources. In *The Organization of Communities: Past and Present.* (Gee J. H. R. & Giller P. S. eds), Symposium of the British Ecological Society No. 27, pp. 29–51. Blackwell Scientific Publications, Oxford
- Shorrocks B., Rosewell J. & Edwards K. (1990) Competition on a divided and ephemeral resource. II. Association. *Journal of Animal Ecology*, **59**, 1003–7
- Silliman R. P. & Gutsell J. S. (1958) Experimental exploitation of fish populations. Fishery Bulletin, Fish Wildlife Service. U.S., 58, 215–41
- Silvertown J. W. (1982) Introduction to Plant Population Ecology Longmans, London
- Silvertown J. W. & Lovett Doust J. (1993) Introduction to Plant Population Biology. Blackwell Scientific Publications, Oxford
- Simberloff D. S. (1976) Experimental zoogcography of islands: effects of island size. *Ecology*, **57**, 629–48
- Simberloff D. S. & Abele L. G. (1976) Island biogeography and conservation practice. *Science*, 191, 285–6
- Sinclair A. R. E. (1975) The resource limitation of trophic levels in tropical grassland ecosystems. *Journal of Animal Ecology*, 44, 497–520
- Sinclair A. R. E. (1989) Population regulation in animals. In Ecological Concepts. (Cherrett, J. M. ed.), Symposium of the British Ecological Society, No. 29, pp. 197–241. Blackwell Scientific Publiations, Oxford
- Sjögren P. (1991) Extinction and isolation gradients in metapopulations: the case of the pool frog (*Rana lessonae*). *Biological Journal of the Linnean Society*, **42**, 135–47
- Skellam J. G. (1972) Some philosophical aspects of mathematical modelling in empirical science with special reference to ecology. In *Mathematical Models in Ecology*. (Jeffers J. N. R. ed.), Symposium of the British Ecological Society, No. 12, pp. 13–29. Blackwell Scientific Publiations, Oxford
- Slade N. A. (1977) Statistical detection of density dependence from a series of sequential censuses. *Ecology*, **58**, 1094– 1102
- Slobodkin L. B. & Richman S. (1956) The effect of removal of fixed percentages of the newborn on size and variability in populations of *Daphnia pulicaria* (Forbes). *Limnology and Oceanography*, 1, 209–37
- Smith F. E. (1961) Density dependence in the Australian thrips. *Ecology*, **42**, 403-7

- Snaydon R. W. (1991) Replacement or additive designs for competition studies? *Journal of Applied Ecology*, 28, 930–46
- Snyman A. (1949) The influence of population densities on the development and oviposition of *Plodia interpunctella* Hubn. (Lepidoptera). *Journal of the Entomological Society of South Africa*, 12, 137–71
- Solomon M. E. (1949) The natural control of animal populations. *Journal of Animal Ecology*, 18, 1–35
- Solomon M. E. (1964) Analysis of processes involved in the natural control of insects. *Advances in Ecological Research*, 2, 1–58
- Solomon M. E. (1969) Population Dynamics. Edward Arnold, London
- Southern H. N. (1970) The natural control of a population of tawny owls (*Strix aluco*). *Journal of Zoology*, **162**, 197–285
- Southwood T. R. E. & Reader P. M. (1976) Population census data and key factor analysis for the viburnum whitefly, *Aleurotrachelus jelinekii* (Fraunenf.), on three bushes. *Journal* of *Animal Ecology*, **45**, 313–25
- Spitters C. J. T. (1983) An alternative approach to the analysis of mixed cropping experiments. 1. Estimation of competition coefficients. Netherlands Journal of Agricultural Science, 31, 1–11
- Spradbery J. P. (1970) Host finding by *Rhyssa persuasoria* (L.), an ichneumonid parasite of siricid woodwasps. *Animal Behaviour*, **18**, 103–14
- Stephens D. W. & Krebs J. R. (1986) Foraging Theory. Princeton University Press, Princeton
- Stiling P. (1988) Density-dependent processes and key factors in insect populations. *Journal of Animal Ecology*, 57, 581–93
- Stimson J. S. (1973) The role of territory in the ecology of the intertidal limpet *Lottia gigantea* (Gray). *Ecology*. 54, 1020–30
- Stubbs M. (1977) Density dependence in the life-cycles of animals and its importance in *K* and *r*-strategies. *Journal of Animal Ecology*, **46**, 677–88
- Sugihara G. & May R. M. (1990) Nonlinear forecasting as a way of distinguishing chaos from measurement error in a time-series. *Nature*, **344**, 734–41
- Symonides E. (1979) The structure and population dynamics of psammophytes on inland dunes. III. Populations of compact psammophyte communities. *Ekologia Polska*. **27**, 235–57
- Symonides E. (1983) Population size regulation as a result of intra-population interactions. I. Effect of density on survival and development of individuals of *Erophila verna* (L.) C.A.M. *Ekologia Polska*, **31**, 839–82
- Takahashi F. (1968) Functional response to host density in a parasitic wasp, with reference to population regulation. *Researches in Population Ecology*, **10**, 54–68
- Tamm C. O. (1956) Further observations on the survival and flowering of some perennial herbs. *Oikos*, **7**, 274–92

- Taylor A. D. (1993) Heterogeneity in host–parasitoid interactions: the 'aggregation of risk' and the ' $CV^2 > 1$ rule'. Trends in Ecology and Evolution, **8**, 400–5
- Taylor L. R. (1986) Synoptic dynamics, migration and the Rothamstead Insect Survey. *Journal of Animal Ecology*, 55, 1–38
- Thomas C. D. & Harrison S. (1992) Spatial dynamics of a patchily distributed butterfly species. *Journal of Animal Ecology*, 61, 437–46
- Thomas W. R., Pomerantz M. J. & Gilpin M. E. (1980) Chaos, asymmetric growth and group selection for dynamical stability. *Ecology*, **61**, 1312–20
- Thompson D. J. (1975) Towards a predator-prey model incorporating age-structure: the effects of predator and prey size on the predation of *Daphnia magna* by *Ischnura elegans*. *Journal of Animal Ecology*, **44**, 907–16
- Thompson K. & Grime J. P. (1979) Seasonal variation in the seed banks of herbaccous species in ten contrasting habitats. *Journal of Ecology*, 67, 893–921
- Tilman D. (1976) Ecological competition between algae. Experimental confirmation of resource-based competition theory. *Science*, **192**, 463–5
- Tilman D. (1977) Resource competition between planktonic algae: an exprimental and theoretical approach. *Ecology*, 58, 338–48
- Tilman D. (1980) Resources: a graphical-mechanistic approach to competition and predation. *American Naturalist*, 116, 362–93
- Tilman D. (1982) Resource Competition and Community Structure. Princeton University Press, Princeton
- Tilman D., Kilham S. S. & Kilham P. (1982) Phytoplankton community ecology: the role of limiting nutrients. *Annual Reviews of Ecology and Systematics* 13, 349–72
- Tinbergen L. (1960) The natural control of insects in pinewoods. 1: Factors influencing the intensity of predation by songbirds. *Archives Neerlandaises de Zoologie* 13, 266–336
- Turchin P. (1990) Rarity of density dependence or population regulation with lags? *Nature*, **344**, 660–3
- Turchin P. & Taylor A. D. (1992) Complex dynamics in ecological time series. *Ecology*, 73, 289–305.
- Turnbull A. I. (1962) Quantitative studies of the food of Linyphia triangularis Clerck (Aranaea: Linyphiidae). Canadian Entomologist, 94, 1233–49
- Turnbull A. L. (1964) The searching for prey by a webbuilding spider Archaeranea tepidariorum (C. L. Kock). Candaian Entomologist, 96, 568–79
- Tybjerg H. & Vestergaard P. (1992) Growth dynamics in the rhizomatous herb *Polygonatum verticillatum Oikos*, **65**, 395– 408
- Ullyett G. C. (1949a) Distribution of progeny by *Chelonus texanus* Cress. (Hymenoptera: Braconidae). *Canadian Entomologist*, **81**, 25–44

- Ullyett G. C. (1949b) Distribution of progeny by Cryptus inornatus Pratt (Hymenoptera: Ichneumonidae). Canadian Entomologist, 81, 285–99
- Uranov A. A. (1975) Age spectrum of the phytocoenopopulation as a function of time and energetic wave processes. *Biologicheskie Nauki*. 2, 7–34
- Usher M. B. (1972) Developments in the Leslie matrix model.
 In: Mathematical Models in Ecology (Jeffers J. N. R. ed.),
 Symposium of the British Ecological Society, No. 12,
 pp. 29–60. Blackwell Scientific Publications, Oxford
- Usher M. B. (1974) Biological Management and Conservation. Chapman & Hall, London
- Usher M. B., Longstaff B. C. & Southall D. R. (1971) Studies on populations of *Folsomia candida* (Insecta: Collembola): the productivity of population in relation to food and exploitation. *Oecologia*, 7, 68–79
- Utida S. (1950) On the equilibrium state of the interacting population of an insect and its parasite. *Ecology*, **31**, 165–75
- Utida S. (1957) Cyclic fluctuations of population density intrinsic to the host parasite system. *Ecology*, **38**, 442–9
- Utida S. (1967) Damped oscillation of population density at equilibrium. *Researches in Population Ecology*, **9**, 1–9
- Vance R. R. (1972a) Competition and mechanism of coexistence in three sympatric species of intertidal hermit crabs. *Ecology*, 53, 1062–74
- Vance R. R. (1972b) The role of shell adequacy in behavioural interactions involving hermit crabs. *Ecology*, **53**, 1075–83
- Vandermeer J. H. (1972) Niche theory. Annual Review of Ecology and Systematics, 3, 107–32
- Vandermeer J. H. (1989) Ecology of Intercropping. Cambridge University Press, Cambridge
- van der Meijden E. (1971) Senecio and Tyrio (Callimorpha) in a Dutch dune area. A study on an interaction between a monophagous consumer and its host plant. Proceedings of the Advanced Study Institute on 'Dynamics of Numbers in Populations' (den Boer P. J. & Gradwell G. R. eds). Pudoc, Wageningen
- Varley G. C. (1947) The natural control of population balance in the knapweed gall-fly (*Urophora jaceana*). *Journal of Animal Ecology*, 16, 139–87
- Varley G. C. & Gradwell G. R. (1960) Key factors in population studies. *Journal of Animal Ecology*, 29, 399–401
- Varley G. C. & Gradwell G. R. (1963) The interpretation of insect population changes. Proceedings of the Ceylon Association for the Advancement of Science, 18, 142–56
- Varley G. C. & Gradwell G. R. (1970) Recent advances in insect population dynamics. *Annual Review of Entomology*, 15, 1–24
- Varley G. C., Gradwell G. R. & Hassell M. P. (1975) Insect
 Population Ecology. Blackwell Scientific Publications, Oxford
 Vickery W. L. & Nudds T. D. (1984) Detection of density

- dependent effects in annual duck censuses. *Ecology*, **65**, 96–104
- Vickery W. L. & Nudds T. D. (1991) Testing for densitydependent effects in sequential censuses. *Oecologia*. 85, 419–23
- Volterra V. (1926) Variations and fluctuations of the numbers of individuals in animal species living together. (Reprinted, 1931, in R. N. Chapman, *Animal Ecology*, McGraw-Hill, New York)
- Watkinson A. R. (1980) Density-dependence in single species populations of plants. *Journal of Theoretical Biology*, **83**, 345–57
- Watkinson A. R. (1981) Interference in pure and mixed populations of Agrostemma githago. Journal of Applied Ecology, 18, 967–76.
- Watkinson A. R. (1983) Factors affecting the density response of *Vulpia fasiculata*. *Journal of Ecology*, **70**, 149–61
- Watkinson A. R. (1984) Yield-density relationships: the influence of resource availability on growth and self-thinning in populations of *Vulpia fasiculata*. *Annals of Botany*, **53**, 469–82
- Watkinson A. R. (1985) On the abundance of plants along an environmental gradient. *Journal of Ecology*, **73**, 569–78
- Watkinson A. R. & Harper J. L. (1978) The demography of a sand dune annual *Vulpia fasiculata*: I. The natural regulation of populations. *Journal of Ecology*, **66**, 15–33
- Watkinson A. R. & White J. (1985). Some life history consequences of modular construction in plants. *Philo-sophical Transactions of the Royal Society of London B*, 313, 31–51
- Watson A. (1967) Territory and population regulation in the red grouse. Nature, 215, 1274–5
- Watson D. (1987) Aspects of the population ecology of *Senecio* vulgaris L. Unpublished PhD thesis, University of Liverpool
- Watt K. E. F. (1968) Ecology and Resource Management. McGraw-Hill, New York
- Way M. J. & Cammell M. (1970) Aggregation behaviour in relation to food utilization by aphids. In *Animal Populations* in *Relation to their Food Resources* (Watson A. ed.), pp. 229-47. Blackwell Scientific Publications, Oxford
- Weiner J. (1993) Competition, herbivory and plant size variability: *Hypochaeris radiacata* grazed by snails (*Helix aspersa*). *Functional Ecoloy*, **7**, 47–53
- Weir D. A. (1985) The population ecology and clonal structure of two grasses. Unpublished PhD thesis, University of Liverpool.
- Weller D. E. (1990) Will the real self-thinning rule please stand up? A reply to Osawa & Sugita. *Ecology*, 71, 1204–7
- Werner P. A. (1979) Competition and coexistence of similar species. In *Topics in Plant Population Biology*. (Solbrig O. T., Jain S., Johnson G. B. & Raven P. H. eds), pp. 287–310. Macmillan, London

- Werner P. A. & Platt W. W. (1976) Ecological relationships of co-occurring golden rods (Solidago: Compositae). American Naturalist, 110, 959–71
- Westley L. C. (1993) The effect of inflorescence bud removal on tuber production in *Helianthus tuberosus* L. (Asteraceae). *Ecology*, 74, 2136–44
- Westoby M. (1984) The self-thinning rule. Advances in Ecological Research, 14, 167–225
- White J. (1980) Demographic factors in populations of plants.
 In Demography and Evolution in Plant Populations, (Solbrig O. T. ed.), pp. 21–48. Blackwell Scientific Publications, Oxford
- White J. (1985) The thinning rule and its application to mixtures of plant populations. In *Studies on Plant Demography* (White J. ed), pp. 291–309. Academic Press, London
- White T. C. R. (1978) The importance of a relative shortage of food in animal ecology. *Oecologia*, **33**, 71–86.
- Whitham T. G. & Mopper, S. (1985) Chronic herbivory: impacts on architecture and sex expression on pinyon pine. Science, 228, 1089–91
- Whittaker J. B. (1979) Invertebrate grazing, competition and plant dynamics. In *Population Dynamics*. (Anderson R. M., Turner B. D. & Taylor L. R. eds), pp. 207–22. Blackwell Scientific Publications, Oxford
- Willey R. W. & Heath S. B. (1969) The quantitative relationships between plant population and crop yield. Advances in Agronomy, 21, 281–321
- Williams A. G. & Whitham T. G. (1986) Premature leaf abscission: an induced plant defense against gall aphids. *Ecology*, 67, 1619–27
- Williams C. B. (1964) Patterns in the Balance of Nature and

- Related Problems in Quantitative Ecology. Academic Press, New York
- Williamson M. (1972) Analysis of Biological Populations. Edward Arnold, London
- Williamson M. (1981) *Island Populations*. Oxford University Press, Oxford
- Wilson D. E. & Janzen D. H. (1972) Predation on *Scheelea* palm seeds by bruchid beetles: seed density and distance from the parent palm. *Ecology*, **53**, 954–9
- Woiwod I. P. & Hanski, I. (1992) Patterns of density dependence in moths and aphids. *Journal of Animal Ecology*, 61, 619–29
- Wolf L. L. (1969) Female territoriality in a tropical hummingbird. Auk, 86. 490–504.
- Wynne-Edwards V. C. (1962) Animal Dispersion in Relation to Social Behaviour. Oliver & Boyd, Edinburgh
- Wynne-Edwards V. C. (1977) Intrinsic population control and introduction. In *Population Control by Social Behaviour* (Ebling F. J. & Stoddart D. M. eds), pp. 1–22. Institute of Biology, London
- Yoda K., Kira T., Ogawa H. & Hozumi K. (1963) Self thinning in overcrowded pure stands under cultivated and natural conditions. *Journal of Biology, Osaka City University*, 14, 107–29
- Yodzis P. (1989) Introduction to Theoretical Ecology. Harper & Row, New York
- Zeide B. (1987) Analysis of the -3/2 power law of self-thinning. *Forest Science*, **33**, 517-37